

REPORT

ON

BAIE VERTE CANAL

BY

SAMUEL KEEFER, C. E.

18 FEBRUARY, 1879.

WITH Mr. GZOWSKI'S APPROVAL PREFIXED.

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REPORT ON BAIE VERTE CANAL.

OTTAWA, 19th FEBRUARY, 1873.

THE HONORABLE H. L. LANGEVIN, C. B., MINISTER OF PUBLIC WORKS, OTTAWA.

SIR,

After having given Mr. Keefer's exhaustive report on the Bay Verte Canal the best consideration I am able to apply to that subject, I fully endorse the conclusions he has arrived at both as to the selection of the best and most efficient line for the Canal; the proposed mode of construction, and his estimate of its cost.

He has located the Canal on the shortest route between Bay Verte and Cumberland Basin with the lowest summit, therefore requiring least amount of lockage and the smallest amount of earth and rock excavation.

The entrances to the Canal are safe and obtained at less cost in the erection of piers, &c., &c., than on any of the other suggested routes.

The provision for the supply of water based on the largest amount of traffic each way is more than sufficient.

I would however recommend that the cutting through rock at the summit of the Canal be reduced from 100 to 50 feet in width. The length of this cutting being only about $1\frac{1}{2}$ mile, a width of 50 feet will in my opinion be sufficient, and whilst it will not injuriously affect the traffic on the Canal, it will materially reduce the cost of construction.

In regard to the plan suggested by Mr. Keefer of making use of the power of the tide to remove a very large portion of the earth from the prism of the Canal, it must be said that considerable advantage will be derived from the plan, if it should as I have every reason to believe it will work satisfactorily.

It will have the effect of reducing the cost of earthwork and the regular semi-diurnal action will secure constant progress irrespective of weather and independant of manual labour, a very important question at present.

I would at the same time suggest that in the arrangement of carrying on the work according to Mr. Keefer's plan and his recommendation to let the portion from Laplanche to Tidnish in one contract at a bulk sum, that care be taken in the selection of the parties to whom the execution of the work will be entrusted.

The plan proposed is simple, but it requires to be carried out by men of experience, intelligence, and possessed of means sufficient to secure the required plant, such as Dredges, Harrows, appliances for rapidly removing boulders, &c., &c., and such other mechanical aid, as may appear to be necessary, and as will suggest itself during the progress of the work.

I have the honor to be

Sir,

Your obedient servant,

C. S. GZOWSKI.

BAIE VERTE CANAL.

REPORT ON THE LOCATION SURVEY OF THE LAPLANCHE AND TIDNISH LINE.

To the Honorable H. L. Langevin, C. B., Minister of Public Works, Ottawa.

Sir,

The location survey of the Baie Verte Canal, on the Laplanche and Tidnish line, as recommended by me and approved by Mr. Gzowski in our report of the 27th August last; and for which I received your authority on the 10th September last is completed, and I have now the honor to submit the following report and plans in reference thereto.

The plans accompanying this report embrace the two lines explored in New-Brunswick under your authority of the 7th November last, one by the Memramcook, and the other by the bend of the Peticodiac and Shediac Harbour, and are such, I trust, as will for ever set at rest the question of the best route for the Canal.

The plans and documents submitted with this report are :

- I. Mr. Stark's report on the surveys, with his plan and profile of the location survey of the Laplanche and Tidnish line, and his plan and profiles of the lines explored in New-Brunswick by Memramcook and Moncton to Shediac.
- II. Comparative profiles of the six projected lines between the Bay of Fundy and the Northumberland Straits, namely :—
 1. The Laplanche and Tidnish line as located under my directions.
 2. The Laplanche and Tidnish line according to the Departmental survey.
 3. The Missiquash line according to the Departmental survey.
 4. The Au Lac and Tidnish according to the Departmental survey.

5. The Memramcook and Shediac line according to Mr. Stark's survey.

6. The Peticodiac and Shediac line according to Mr. Stark's survey.

These profiles are all drawn to the same scale 40 feet to an inch vertical, and 2,000 feet to an inch horizontal, and present a clear distinct picture to the eye of the relative amount of work to be encountered in each.

III. A general Map of the Isthmus of Chignecto and of a portion of New-Brunswick, showing the several lines projected for a Ship Canal to connect the waters of the Bay of Fundy with those of the Northumberland Straits at Baie Verte and Shediac Bay, compiled from the admiralty charts and from recent surveys of the Department of Public Works.

APPENDIX CONTAINING :

(1.) Comparative statement of quantities of work to be performed on the located line and other proposed lines between the Bay of Fundy and the Northumberland straits.

(2.) Copy of Memorandum on Baie Verte Canal, by Messrs. Gzowski and Keefer, 2nd May 1872.

(3.) Copy of their 2nd report on same subject, 22nd May 1872.

(4.) Copy of 3rd report, on same subject, 27th August 1872.

(5.) Copy of sailing directions Gulf and River St. Lawrence, (1871), relating to Pugwash, Baie Verte and Shediac Harbours including Cape Tormentine.

(6.) Copy of sailing directions Bay of Fundy, Chignecto Bay and Cumberland Basin extracted from sailing directions of Commander G. F. McDougall, R. N. 1871.

The difficulties to be encountered in the construction of a Ship Canal through this Isthmus, are no doubt of a formidable character, and in some respects peculiar. Nature has interposed a barrier between the waters which they cannot pass without serious effort from the art of man. Where the land divides the streams that flow to either bay, we might naturally expect to find a barrier of solid rock. This has been traced out and measured and at the very lowest point it has been ascertained to be a mile and a half across with 15 feet of the crest to be cut through. The material is a soft red sandstone. Throughout the rest of the summit level it will be necessary to cut a Canal 22 feet deep through Clay to give a safe 15 feet navigation.

But the tidal phenomena are those which present the greatest difficulties, and they are such as the history of engineering furnishes no example. The entrances to the Canal, are likewise beset with difficulties, but it is believed that none of these are insurmountable. With care and skill, and the judi-

cious application of the same principles, as have guided and governed the construction of the great engineering works of the day, the opening of a canal by the line I have selected is not only practicable and feasible, but can be executed at a reasonable cost.

THE LAPLANCHE AND PIDNISH LINE.

This line has been located by M. Stark, for the most part, in strict accordance with the course indicated for it in my report of the 27th August last, after having made my first personal examination of the ground. The only variation from the projected line is at the summit between the bays. Here it was found after passing Long Lake that the lowest ground did not represent the least work: for by swerving to the eastward he found the watershed occupied by a deep spongy moss resting on what might in former ages have been a lake, but which is now wholly occupied by this vegetable growth, for a space of a quarter of a mile in width, a mile and a half in length and for a depth varying from 10 to 20 feet, the greatest depth being in the middle. Mr. Stark reports the substance of this moss as "entirely free from any mixture of sand or soil, being simply a growth of vegetation."

Under this moss we find the red clay from 10 to 15 feet deep resting on the old red sand stone, the surface of which is a little below the low water surface of the canal. This sandstone is a very soft rock to excavate, and is by no means a serious obstacle to the construction of a canal. It is believed that the moss when drained can mostly be removed by burning, and so reduce the summit excavation to an average depth of 28 feet at the passing of the watershed. The located line passes lengthwise through this moss.

To ascertain the feasibility of the canal, the discovery of a practicable pass through this watershed was the first object to which attention was directed. The facts which have been developed by the survey have put the matter beyond question, as may be seen by reference to Mr. Sark's report, as well as to the comparative profiles, and the comparative statement of quantities herewith submitted. Entertaining no doubt on this point the centre line of the canal has been established throughout and the nature of the soil examined by borings at intervals of 500 to 1,000 feet. The profile furnished by Mr. Stark represents, in this approximate way, the quantity of clay, sand, rock and moss likely to be found in the excavation.

It is not improbable that some further improvement may yet be made in the location so as to avoid rock cutting, but in other respects the line which has been run out may be considered as final, and the work may be laid out from it.

This line begins at the Mouth of the Laplanche as before stated and runs in a straight line to Fox's Point. Crossing the Intercolonial Railway at the

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bend of the Laplanche. From Fox's Point it trends to the westward, passing over low wet ground to Long Lake.

It passes through this lake, through the mossy swamp before described, through the Black ash swamp and descends the little west Branch of the Tidnish, and locks down into the Tidnish a little above Doyle's Mill. Thence to Baie Verte the canal will occupy the main Channel of this river, which is to be raised 5 feet over high water of Baie Verte by a dam across its mouth, and the channel straightened by cuts across the flats at the base of the upland ridges. The tide now flows up the Tidnish as far as Doyle's Mill Dam, and the raising of that River 5 feet for the purpose of reducing the quantity of excavation will render it necessary to cancel this Mill privilege. The canal with this raised level is to be carried across the point of lowland to Tidnish head, and thence by a sea embankment $2\frac{1}{2}$ miles long over the shallows of the bay to the 4th Lock which is to be placed under shelter of the rocky reef projecting out from Wick's Point (called Roache's Head in the admiralty charts) and joined to the main land by another embankment 1,600 feet in length, run out from that point. The two parallel entrance piers at this end of the canal will be about 1,800 feet in length, and will run out in a N. N. E. direction to 15 feet water at low water. At the south end of the canal there will be but one pier which will be placed on the west side. Its length will be about 2,500 feet. It will be backed up on the west side by the earth taken from the excavation of the Lock pit.

There will be four locks on this Canal, one of which, the 2nd from Cumberland Basin will be a guard lock with reverse gate to keep out all spring tides above +92 which represents the high water surface of the Canal and corresponds with the present level of Long Lake. The first lock will be situated just within the mouth of the Laplanche where, lying embayed, it will be protected from the strong tidal currents flowing to and from the Macan and Hebert Rivers, and from the winds which sweep up the Bay of Fundy by the protecting point formed by the Minudie (*Main-à-Dieu*) Marshes.

The second lock will be separated from the first by a basin 600 feet in length. These two locks must have their walls carried up to the same height.

The first will have a lift varying from 0 to 12 feet, the second a lift varying from 0 to 10 feet towards Bay of Fundy, and from 0 to 10 feet towards Baie Verte.

The 3rd lock, near Doyle's Mill, will have a lift varying from 4 to 10 feet, and the 4th lock at Week's point a lift varying from 5 to 15 feet.

The summit level between the 2nd and 3rd locks is $12\frac{1}{2}$ miles long and will have a variable surface of 6 feet below Long Lake in order to provide storage for an adequate supply of water for the navigation. High water in this level will be 92 feet above datum and will be on a level with Long Lake and the series of small lakes at the head of the Laplanche, while low water

will be 86 feet above datum.—Datum being assumed 50 feet under ordinary low water as in the Departmental Survey.

The sills of the entrance lock at the mouth of the Laplanche will be placed at +55 above Datum so that vessels of 15 feet draught can enter when the water stands at +70.

The mean level of the sea as reduced from the tidal observations of the Departmental Survey is found to be + 71, 60 above datum, so that the Canal can be used for $12\frac{1}{2}$ out of every 24 hours.

It is one of the remarkable results of this survey, and goes to confirm the accuracy of the tidal observations, that the mean level of the sea is found to be the same in both bays—namely + 71, 60 above datum.

The sill of the entrance lock at Baie Verte will be placed at +52 above datum in order that vessels may enter it at any time of tide. This is done because it is so easy to make provision for continuous lockage at this end of the Canal. It is only necessary to sink the lock sills and entrance piers 3 feet lower than at the west and to gain this great advantage for vessels entering and departing from this end of the canal.

The length of the second reach, between the 3rd and fourth locks is 7 $\frac{7}{10}$ Miles.

The total length of the Canal between the entrance locks on the located line is $20\frac{1}{2}$ miles.

The direct course on an air line from the mouth of the Laplanche to Tidnish Head is 17. 10 miles. The distance between the same points on the located line is 18. 37 miles; the difference being due to the fact that to save cost the canal has followed the lowest ground through the summit, and then several windings of the Tidnish Valley.

The bottom of the summit level having been assumed at + 70 above datum. The general depth of cutting through the marshes will be 22 feet. The highest point on this summit is on the moss already described 48 feet, above Canal bottom and deducting from this 20 feet for the thickness of the moss, the solid excavation across the water-shed is reduced to 28 feet as before stated, or only 6 feet above the general level of the marshland.

For a canal of the dimensions recommended by the Canal Commission, 100 feet at bottom with 16 feet depth of water to afford 15 draught for vessels, with slopes in clay 2 to 1, and in rock $\frac{1}{2}$ to one, Mr. Stark reports that the total quantity of earth excavation on the located line will be 9,160,000 of rock excavation 440,000 and of the moss most of which can be } removed by draining and burning, } 1,090,000

The quantity of rock excavation may be materially reduced by (1) shifting the line so as to avoid the 40,000 cubic yards shown on the profile at Black

Point and Fox's Point, and (2) by reducing the bottom width of the rock cutting through the watershed to 50 feet. But in order to make a fair comparison of this line with the other projected lines it is considered proper to state the full quantities.

THE MECHANICAL STRUCTURES.

Besides the four locks before mentioned, there will be required for the proper furnishing and service of this canal.

A supply and stopgate at the bend of the Laplanche near the crossing of the Intercolonial Railway, fitted with reverse gates so as to serve the purpose of supplying and emptying the summit level when required, and high enough to shut out all tides above + 92, the high water level of the canal.

Two waste weirs with flood gates one near the Tyndal Road to let off the flood waters from the summit level into the Tidnish, and the other in the Dam at the mouth of the Tidnish. These must be constructed to regulate the water level in the first and second reaches and also to afford the means of emptying those reaches for convenience of making repairs.

One single track Railway swing bridge at the crossing of the Intercolonial Railway. It will be of wrought iron, balanced on a central pier of solid masonry, with two openings of 50 feet each to admit of vessels passing in both directions whenever the Bridge is open.

The abutment walls will likewise be of solid masonry. These and the central pier will be protected by means of pile fenders. The pier and abutments will rest upon a wooden platform extending all across the Canal and sheet piled at the ends to protect the channel from erosion when the water is drawn off to scour out the bottom.

One wooden swing bridge across the chamber of the 2nd lock, and another across the chamber of the 3rd lock. Four common Road Bridges at (1) the Main road between Amherst and Sackville, (2) the Eddy Road, (3) the Tyndal Road and (4) the main road between Baie Verte Village and Pugwash. These four bridges to be of wood, single track and presenting each, one opening of fifty feet. The piers, and abutments to be of pile work protected by pile fenders.

Besides these bridges it may be necessary at certain intermediate stations to provide scows, as on the Beauharnois Canal, for the accommodation of the landed proprietors. These will be moored in little nooks or bays constructed for the purpose, and be worked by wire ropes or chains stretched across the Canal and lying on the bottom.

It will not be necessary, to construct more than one culvert under this canal throughout its whole length from sea to sea. This will be at the bend of the Laplanche near the crossing of the Railway, for the purpose of giving

an outlet for the backwater from the aboideau under the Railway near the crossing.

It may be built of timber, or a cast iron pipe may be laid under the canal to answer the purpose.

WATER SUPPLY.

Without an abundant supply of water the construction of a Canal would be utterly futile, unless it can be clearly shewn, that it is ample to afford continuous lockages in both directions, during the time the Canal can be approached; and a large per centage in addition to make up for leakage and evaporation, this canal should never be undertaken. But I think it must be admitted, from the facts I have to communicate on this point, that this question is placed beyond doubt.

It is proposed as stated in my former report to take the supply from two sources—first, from the high water of the Bay of Fundy; secondly from the freshwater lakes at the sources of the Laplanche. As before stated, Round Lake, Long Lake and the other smaller Lakes which feed the Laplanche are nearly all on the same level, + 92 feet above datum, and on a level with the surface of the Amherst marshes. Indeed between Long Lake and Fox's Point for about $2\frac{1}{2}$ miles in extent the whole country seems to be afloat. The surface of these lakes is therefore assumed as the high water level of the Canal, the lowest being + 86 above datum. This variable level of 6 feet affords the storage for the water to be used for working the Canal.

It will be replenished from time to time, in case of need, by the high waters of Cumberland Basin, whenever they rise over the level of + 86 above datum. And while low water at that basin is exceedingly muddy, the high water is generally pretty clear, and quite as admissible for Canal purposes, as that taken from the Grand River to feed the Welland Canal. No exception can therefore be taken to the admission of any tide water above the low water level of the summit.

The low water level of the summit + 86 corresponds with the average minimum range of high water, taking the lowest neap tides, of each month, as given in the tidal observations of the Departmental survey; so that the maximum range of all neaps above that level, and the whole range of springs up to + 96, the highest observed, are available for the Canal. Although we may not count on the highest observed tides such as + 96, nor yet on the Saxby tide of + 100, as feeders, still they must be garded against; but we may reasonably take the average monthly range of spring tides + 94 as deduced from the survey, or 2 feet above the assumed High Water of the Canal, as a reliable source from whence a supply can be drawn for Canal purposes. This

can be drawn both through the 2nd lock and through the supply gates at the bend of the Laplanche, while these same structures by their reverse gates will serve to shut out the highest tides which cannot with safety be admitted into the Canal.

The quantity of water that can be stored between the fluctuating surfaces of the summit level, six feet deep and $12\frac{1}{2}$ miles long is

69,696,000 cubic feet.

The Lakes however furnish a much larger storage.

The area of Round Lake is.....	7,695,600 sq feet
" of Long Lake.....	10,002,800 "
The other smaller Lakes.....	7,050,000 "
Total.....	24,748,400 "

Not counting the floating boys around these Lakes.

If these lakes are all drawn down 6 feet to feed the Canal at its lowest stage of + 86 above datum, they will afford a supply, or a storage of

$$24,748,400 \times 6 = 148,490,400 \text{ c feet}$$

To this add the storage in the prism of the Canal	69,696,000 c feet
Total.....	218,185,400 "

Being an average for every foot rise of	36,364,400 c feet
or for every inch of rise and fall	3,030,560

It will be shewn that this, with the facilities of replenishment by the tide, is ample for the service of the Canal, but should the future increase of trade hereafter demand a larger water supply, this quantity can be doubled, simply by cutting a Canal 6 feet deep and only one mile in length through the Marsh lands which divide Round Lake on the Laplanche, from Hacamatack Lake on the Missiquash, with other shorter cuts to connect these with Patten Lake, and Long Lake, and the endless series of Lakes forming the source of the Missiquash, the surfaces of which are from 3 to 4 feet above Round Lake—thus uniting the head waters of both rivers, and affording additional fresh water for scouring, and ample storage for the service of the Canal.

The surveys have established the fact that Fort Lawrence ridge, which divides the Laplanche from the Missiquash, is an island in the marsh, so that the series of lakes which empty into each river can easily be united in the manner suggested

THE COMSUMPTION.

The working of the Canal, allowing for continuous lockages in both directions from the summit, and for one lockage every 15 minutes during the 12½ hours out of every 24 hours, demands 50 lockages a day, from each of the summit locks No 2 and 3, equal altogether to 100 lockages a day, or 50 vessels each way in 24 hours.

These locks have lifts varying from 4 to 10 feet.

The average lift of all the locks may be assumed at 8 feet.

Then one lockage will take $270+40+8=86,400$ c. ft. and one hundred lockages will consume..... 8,640,000 c. ft.

Add for 10 lockages towards Baie Verte in consequence of facility of entrance there at all times of tide, which may possibly be continued for 10 days at one time.	864,000 c. feet.
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Add for leakage and scouring.....	2,496,000 "
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Total daily expenditure.....	12,000,000 "
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when the Canal is worked up to its capacity.

Evaporation at the summit level will be compensated for by the rain fall and natural springs which feed these lakes and keep them always full of water, proving by this fact that they are not reduced by evaporation.

As for infiltration there can be little or no waste from that cause, when we reflect that the Canal is to be cut deep into a stiff clay soil already saturated with water and intersected probably by springs; and likewise that there can be no drainage through the banks of the Canal to any lower level.

On the second reach, the Tidnish itself will more than make up for the waste from these causes.

Therefore the lockages, leakage and scouring are the only quantities to be provided for under the circumstances, and the allowance of 12 millions of cubic feet expenditure per day is ample for the requirements.

Then as the volume of waters in the Canal and in the Lakes between +86 and +92 on the summit level, is 218,186,400 c. feet, it will be sufficient to keep the Canal in full operation with 110 lockages a day, for no less than 18 days, without any addition from other sources. But the spring tides which occur about every 14 days will be sure to render that supply continuous.

It will take 30 lockages to reduce the summit level one inch, and the utmost effect of a full days consumption for 110 lockages, would not lower the water more than 4 inches.

These calculations shew that the scheme proposed for the water supply

is a safe one ; at high water in the Canal the draught will be 22 feet, and at low water 16 feet, and it will never be necessary to draw down the level below low water line, except when it may be found desirable to scour out the Canal.

In view of the facts above stated it might be supposed that inasmuch as the draught to be provided for is only 15 feet, the bottom of the Canal might be elevated as much as 2 feet and save so much excavation on the summit level, still leaving a range of 4 feet for the Canal surface, and affording a storage capacity of 145,457,600 cubic feet, equal to 12 days supply. This would appear to be quite safe, but then it must be observed that there would be no means left of draining and improving the lands at the head of these marshes. By keeping the bottom down to +70, and reducing the level of the lakes to +90, sufficient drainage will be afforded for this object : or they may be reduced to a still lower level with better effect, so long as the surface areas are not materially diminished.

HARBOURS.

It is no doubt quite as important that there should be reasonable convenience of access to both ends of the Canal, as that there should be an abundant supply of water for it. Looking first at

BAIE VERTE.

We find a minute description of this bay and the mode of access to it in the sailing directions for the Gulf and River St. Lawrence published in 1871 a copy of which will be found in the appendix.

It will appear from reference to these directions and the admiralty charts, corrected up to 1867 that vessels can have no difficulty in making this entrance to the Canal.

The piers run out from Roache's Head which is situated two miles to the Eastward of Tidnish head, in a N. N. E. direction so as to protect the lock gates from the assault of the sea and to favour the entrance and departure of vessels as much as possible from all winds, more especially, for those from the Eastward.

The entrance to this Canal at Roach's Head is about 10 miles N. N. W. of Pugwash Harbour where, if necessary, vessels approaching from that direction can find good anchorage and shelter until the weather is favourable for running up to the Canal. (See sailing direction in appendix.)

The Canal entrance is protected from northerly and northwesterly winds by Cape Tormentine and from the North Easterly winds by Prince Edward Island. The bay is only open to Easterly winds, and the direction

given to the piers is such as to give us grat facilities as possible for entrance and departure.

BAY OF FUNDY TERMINUS.

The bay of Fundy is remarkable for the extraordinary range of its tides. It is one of the wonders of the world, and the wonder is, that such a prodigious volume of water as enters and leaves it twice a day, does not produce a greater commotion. On the direct course up the Bay to Cumberland Basin and in the Basin itself, there is no bore; the water being too deep, and the course too direct, to admit of such a phenomenon. Having observed the operation of the tides, both at Laplanche and au Lacs, I was surprised to see with what ease and regularity it was done. The surface of the great Basin rises and falls almost imperceptibly all the while preserving, in the absence of any wind, the placid appearance of a Lake.

The range of the tide at Saint John is 27 feet for springs and 23 for neaps, while, according to the Departmental survey, it is 48 feet for springs and 38 for neaps at the head of Cumberland Basin.

Here then, according to the moon's position, and the other causes which influence the tides, the water rises from 19 to 24 feet above the mean level of the sea, and falls from 19 to 24 feet below the same level, twice in every 24 hours. At one time the water is piled up to a height of 24 feet above the average level of the sea, and at another, just so much is taken out of the bay, below that level. Like the oscillations of a pendulum, or the arms of a balance, these vast bodies of water vibrate about the neutral axis, represented by the average level of the sea; and furnish a striking example of the stupendous forces that govern the motion of the tides—yet so gradual are the changes that, with care and skill, this Bay can be navigated, except in bad weather, with perfect safety.

The Admiralty charts and the elaborate departmental survey of this Basin, both shew that the deep water comes up to the mouth of au Lac, and then turns off at right angles $2\frac{1}{2}$ miles along the marsh coast to Laplanche; but it will be observed that the depth is not sufficient for any large vessel to approach either entrance at low water.

According to the sailing directions there is no low water anchorage above Woody point, known as the Sackville anchorage. Above this anchorage it is remarked "only small vessels can lay afloat at low water, but trading craft can lay aground on the mud." A careful study of these charts and directions must satisfy any practical person that it is impossible to place the entrance of the Canal at any point in this basin that will be accessible at all stages of the tide. There is in fact no navigation for vessels of 15 feet draught at low water. They can only begin to move in safety at half tide, or at the level of 70 feet above datum fixed upon for entering the Canal.

So whether the terminus is at Au Lac, or at Laplanche, a half tide canal is all that can be attained. But a terminus at Au Lac, as represented on the Departmental Chart, would expose the lock gates to the direct assault of the sea, and the full force of the south west winds, the heaviest that beat upon this shore. In such a position it would be impossible to maintain the lock gates, and the difficulty for vessels making or leaving the entrance would be serious.

On the other hand by placing the entrance locks embayed in the mouth of the Laplanche, and under cover of Minudie Point and sheltered from the prevailing South-West winds, the gates will be protected from the sea and vessels may enter in safety.

In proof of the statement that the South-West winds act with more force at Au Lac than at Laplanche it is only necessary to refer to the character and condition of the Dykes at each place. At Laplanche they are of simple construction and easily maintained, while at Au Lac they have to be of stronger build and protected from the sea by close piling outside, at a very considerable expense—so great indeed that since the occurrence of the Saxby tide in 1869 many hundreds of acres of valuable marshlands have been abandoned, it being too costly to restore the Dykes.

When the canal is in full operation it will always be necessary to have the modern appliances of steam tugs at each end, and others in the reaches for towing. In adverse winds vessels may remain in the canal until a favorable time comes for being towed out to sea : or if they wish to leave their anchorage outside, they may signal a tug to take them into the canal.

Before the Railway was opened for traffic Amherst received its water-borne supplies at the mouth of Sharp's Creek a mile and a half further up the basin : and although no facilities whatever were created, either here or at the mouth of the Laplanche, trading vessels have frequented these places from time to time whenever there was any business to be done.

We may therefore fairly conclude that with suitable entrance piers at the mouth of the Laplanche a safe and commodious harbour may be formed at this end of the canal : easily accessible at all reasonable times when the flood and ebb tide will permit of entrance. It will not be denied that for at least 3 hours before flood and 3 hours after the ebb vessels can enter in fair weather. This gives 6 hours each tide, or 12 hours a day ; or more likely 12½ hours, as assumed in the scheme now submitted.

Objection may be raised to the plan of a canal which I have submitted, on the ground of it being a whole tide canal at one end, and a half tide canal at the other : and that twice as many vessels can enter it at one end, as can depart from it at the other.

The fact of this anomalous condition is admitted, but will any one propose

to have it changed? If, as has been shewn, we can have only a half-tide canal at the west end, it becomes a choice between having that or none at all. But if we choose to have the canal, it will scarcely be urged, for this reason, that we should aim at nothing more than a half tide canal at the East end, where in consequence of the limited range of the tide, we have only to sink the entrance lock and piers three feet deeper to secure the very great convenience and advantage of an entrance accessible at all times of tide.

But if the physical conditions are such as to preclude the possibility of a whole tide canal throughout, and if the increase of trade should hereafter demand greater accomodation than the single line of locks will afford, then by doubling the locks at Cumberland Basin we can pass as many vessels through them in 12 hours, as can be passed through the single lock at Baie Verte in 24 hours. In this way the conditions could be equalized, and the half tide canal at one end, be made to do as much work as the whole tide canal at the other.

And if it could be shewn that the trade at the outset would demand this accomodation, I would be disposed to go even further, and advise at once to build a set of double combined locks at the Laplanche, because this arrangement, under the circumstances, presents many structural advantages. The more prudent course however, seems to be, to await the result of the opening of the canal, built in the most economical manner, consistent with efficiency; and see what the actual requirements of the trade may be, before embarking in any more expensive works.

THE OTHER PROJECTED LINES.

The second profile on the plan is that of

THE LAPLANCHE AND TIDNISH.

Of the Departmental survey. This, according to the report, is 17.19 miles in length from shore to shore, and 19.63 miles to low water, with 7,200 lineal feet of piers at the west end, and 18,400 feet at the east end. According to the same report the total quantity of excavation on this line is 21,383,847 cubic yards of which 3,686,529 cubic yards are solid rock. The great difference between the quantity of work on this, and on the located line is accounted for, in the first place by the fact that I have selected a lower level for the canal where much less rock is found and where the other excavation is reduced to a minimum. The located line passes through Long Lake a mile to the westward of the point where the above line is in cutting from 30 to 40 feet deeper, and where, as may be seen by the profile, an immense body of solid rock would have to be excavated. In the next place, this line passes directly over the high ground to Tidnish Head, on a shorter course, but encountering no end or unnecessary work.

It will be seen that by descending into the Valley of the Tidnish, locking

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down at Doyle's Mill, and by raising its level 5 feet over high water, a large amount of excavation can be saved

THE MISSIQUASH LINE.

Of the Departmental survey, the third line on the profile, starts from the mouth of the Au Lac sweeps round the base of the Cumberland ridge, and ascends the Missiquash Valley, crossing this river and uniting with the au Lac line, at the head waters of that river. Its length to Tidnish head from shore to shore is 18.86 miles, and between low water at each bay 21.45 miles. It has 4,000 feet lineal of piers at the West end, and 18,400 feet at the East end. The report shews the total quantity of excavation to be 22,640,743 cubic yards, of which 1,207,508 cubic yards are solid rock.

The proper location of a line by the Valley of Missiquash would be as follows : Starting from Cumberland Basin on the West side of Tongues Island, and about half way between that Island and Cumberland Creek, it would pass in a direct line up the valley towards the point where the Province boundary intersects the Missiquash, and then, from a point opposite the tide feeder, proceeds in a straight line through Round Lake until it intersects the recent location of the Laplanche Line. Next to the Laplanche line, this is the most favourable one that could be found. It is but a trifle longer but the quantity of rock and earth excavation would be much greater than on the Laplanche Line.

But the more serious objections to this line are. (1), The exposure of the locks at the Western entrance to the action of the waves, and (2), the interference with the tide feeder for forming Marsh lands. Any canal that is built must be isolated from the river, as well for its own protection, as for leaving open the means of forming new marsh lands.

THE AU LAC AND TIDNISH LINE.

Since the time that Robert C. Minnitte, Land Surveyor, first traced out a line for a Canal between Cumberland basin and Baie Verte, by the Tantamar, Au Lac and Tidnish rivers, in the year 1822, this seems to have been the favoured route. It is recommended by Francis Hall, Civil Engineer, who followed Minnitte's line, pretty closely in 1825. For an 8 feet Navigation with 6 locks $105\frac{1}{2} \times 20\frac{1}{2} \times 8$ feet, he proposed to make use of $3\frac{1}{2}$ miles of the Au Lac from its Junction with the Tantamar, and reported that the length of artificial navigation between Au Lac river and Tidnish, was only 11 miles and 241 yards while the total distance between low water anchorages at either end was $19\frac{1}{2}$ miles. His estimate for a canal of this description was £67,728.14.10.

Mr. Hall's plans were submitted to Thomas Telford, the founder of the Institution of Civil Engineers, who in a report printed without date, and following the line traced out by Mr. Hall, changed the levels, reduced the number of Locks to 4, and furnished an estimate for a canal of 13 feet navigation with locks $150 \times 40 \times 13$ feet, amounting to £155,898.55 sterling. After this, in 1843, we have the examination plans and report of Captain Crawley, Royal Engineers, of the Petitcodiac and Memramcook routes to Shediac, and likewise the Au Lac and Tidsnash, from Cumberland Basin to Baie Verte. While he looked upon the latter as the most natural position for a channel of communication between the Bay of Fundy and the Gulf of St. Lawrence, he considered the construction of any canal of the ordinary description impracticable.

According to the Departmental Survey, the accuracy of which cannot be doubted, the line between Au Lac and Tidsnash Head is 18.84 miles long, from shore to shore, and the total length between low water at each bay, is 21.43 miles. The total quantity of excavation is given in the report at 22,057,633 cubic yards, 2,472,054 cubic yards of which is rock.—The length of piers at the West end is 4,000 feet, and at the East end, 18,400 feet.

Having pointed out the objections to this line in my report of the 27th August last, (see appendix) it is unnecessary to repeat them here. They have been fairly stated, and are sufficient to shew that this line is inadmissible.

MEMRAMCOOK AND SHEDIAC LINE.

A line was explored for a canal between Dorchester Island, on the Bay of Fundy and Shediac Bay up the Valley of Memramcook, by Robert C. Minnitte, as early as 1823, and was afterwards surveyed and reported on by Francis Hall, C. E. in 1825, and by Captain Crawley, Royal Engineers in 1843. Plans and profiles of the first and third mentioned surveys are now in the possession of the Government. It was known the latter had reported "that the deficiency of head water renders the construction of a canal of the ordinary description impracticable," but in consequence of representation made to the Government, while Mr. Stark was engaged in the Location Survey of the Laplanche line, I received your instructions to have this, and the Moncton line examined once more. The principal object of this survey was to see that the projected lines in New-Brunswick had received proper engineering treatment in previous explorations, and to test the accuracy of previous surveys. As soon therefore as this test was applied the further prosecution of the surveys was discontinued. It was considered useless to expend any more time and money upon lines, which were found on first examination to illustrate in the most forcible manner what Captain Crawley meant when he designated them as "*impracticable*."

To be satisfied of this, it is only necessary to look at the sheet of comparative profiles, herewith submitted, and to consider the following statement.

The Memramcook line from shore to shore is 22.92 miles long, and from end to end of entrance piers, 25.59 miles. The quantity of excavation is not given because of the considerations which follow.

If there was water to supply the canal at the summit, 16 locks would be required, and 28,200 lineal feet of pier work, but as all the water available is only a fractional portion of the quantity required for working the canal, the construction of locks is not to be entertained.

Then if we have the hardihood to look at a thorough cut through the country for a tide canal, it will be seen to require an excavation through rock and earth 25 miles long, and a 115 feet deep at the summit. The cubic contents of such a cutting would be prodigious.

THE MONCTON AND SHEDIAC LINE.

This line is even less favourable for a canal than the Memramcook, and the quantities of excavation are not given for the same reason. It is supposed that the mere statement of the facts of the survey are sufficient to satisfy any one that it cannot for a moment be entertained.

The length of artificial navigation, were any navigation possible, would be 34.69 miles, and the number of locks, if there were any water to work them, would be nineteen.

The only source of supply for a canal from Moncton to Shediac is a little basin among the hills known as Humphrey's Pond about 500 acres in extent, with a very limited drainage area to feed it. It is now used for milling purposes.

Should the construction of a tide canal be propounded, it would require a thorough cut of 17 miles in length, between Moncton and Shediac and 150 feet deep at the summit. It would also be necessary to throw a dam across the mouth of the Petitcodiac, in order to kill the bore, and make slackwater navigation up to Moncton, a distance of 17 miles more, through the most of which a channel would have to be dredged.

I think it is only necessary to state these leading facts in regard to the projected lines through New Brunswick, between the Bay of Fundy and Shediac to shew conclusively, that the idea of constructing a navigable canal either by Memramcook or Moncton is not to be entertained, and is not worthy of serious discussion.

THE ESTIMATE.

My estimate of the cost of constructing a canal of the dimensions recommended by the Canal Commission 100 feet at bottom and 15 feet clean

draught of water, with locks 270 + 40 + 15 by the Laplanche and Tidnish line located by Mr. Stark, is

\$5,317,000.

But if the rock excavation be reduced to 50 feet in width at bottom as herein suggested the estimate in this case will be

\$5,000,000.

This estimate is made up of the following items.

	C. yds.	
For Excavation {	In earth.....	9,160,000
	In rock	440,000
	Moss	1,090,000
		\$3,517,000
For embankments Baie Verte.....		268,000
For 4 Locks.....		793,000
For one Railway and 4 common road bridges.....		69,000
For entrance Piers at Bay of Fundy and Baie Verte.....		365,000
For Tidnish dam and for waste weirs and stop gates.....		105,000
For land, land damages, damages to property, engineering and superintendence.....		200,000

THE METHOD OF PROCEEDING WITH THE WORK.

The foregoing estimate is based on the supposition, that the whole of earthwork including clay, sand and muck shall be removed by manual labour, or by mechanical means of some sort, and at prices sufficient to cover the cost of performing the work in the ordinary manner.

I propose however to remove the principal part of this earthwork — it is impossible to say how much — by means of the tidal power of the Bay of Fundy.

From the foregoing description of the tidal phenomena, in this wonderful bay as well as from a consideration and appreciation of the scouring effect of the tides as seen in the four rivers which drain the Amherst and Sackville marshes, unassisted by art; as well as in the tide feeders constructed for making new marine marsh lands, it will be understood that these forces are very great, and yet that they can be turned to useful purposes.

It is well known that the scouring effect of the tide is in direct proportion to the fall and volume of the water employed in the operation.

It is proposed, in the first place, to excavate through the marsh lands on the summit level, and in the axis of the canal, a channel fifty four feet wide at surface, eighteen feet wide at bottom and eighteen there profected abouts; and with the material taken from this cut to form embankments on either

side, at proper distances from the centre line to allow for the full width of the canal, including its slopes and berms. These banks to serve as dykes effectually to isolate the canal from the adjacent lands; and to be raised to 102, or two feet above the Saxby tide. They will be ten feet high above the marsh and twenty feet wide at top, and thus form a good waggon road on both sides of the canal, which will be of great convenience in carrying on the works.

This gullet with its attendant dykes is to be carried from the mouth of the Laplanche all across the marsh lands and through Long Lake to the highland at the watershed, and again from the East side of this dividing ridge to the site of the third lock on the Tidnish River.

One or more gullets of smaller dimensions are to be cut through the moss at the summit, to drain it and dry it up so that it can be burned. When this is accomplished, a channel is to be cut through the earth and rock at the summit, of such dimensions as may be considered best, and at some convenient point in this channel a temporary guard and stop gate will be placed to afford the means of controlling the current through it. Another temporary stop gate may be necessary between the second lock and the Intercolonial Railway, but this is not considered imperative.

While this work is in progress steam dredges are to be set at work on the Tidnish to straighten the channel across the flats, and to deposit the stuff taken there from into the bends of the old crooked channel, so as to give a proper direction to the current which is designed to enlarge and complete it.

It will be necessary to proceed at once with the construction of the swing bridge for the Intercolonial Railway, as before described, taking care that the work is performed in the most perfect manner so as to prevent the possibility of that important structure being affected by the scouring current either during the construction of the canal or after it is open for traffic.

Temporary fixed bridges may be thrown over this channel where it crosses the common roads, and protected by piles brush and stones if necessary.

The permanent supply and stop gates at the bend of the Laplanche may also be proceeded with at once, but it will be better not to commence the first, second and third locks until the channel has been scoured out, — but in the mean time the materials for them may be delivered and prepared for building.

The cut across the Tidnish point however, and the construction of the sea embankment, forming the basin above lock No. 4, as well as the lock and piers may be commenced and proceeded with immediately after the work is let.

Then, when all these works are properly provided for, and the channel cut through the summit; and an out-fit of steam dredges, tugs, scows, and

harrows has been provided, and a telegraph established for instantaneous communication from end to end of the canal, the high water of Cumberland basin may be admitted into it and allowed to take its course freely to Baie Verte, and its effect during each tide carefully noted.

According to the state of the tides the fall from Bay of Fundy to Baie Verte, at high water, will vary from 14 to 24 feet, producing a velocity, if uniform throughout varying from 2 to $5\frac{1}{2}$ miles an hour, the least of which is, sufficient to sweep along sand, gravel and rounded pebbles. The scour may be increased, checked or altogether stopped at any time, and twice a day the channel will be laid bare for inspection, so that its progress may be seen and regulated. During the continuance of this tidal scour which will be materially assisted by the back water from the lakes, the dredges, scows and harrows should be kept at work breaking down the harder parts of the slopes and bottom, removing stones and so giving proper direction to the current.

The floating bog below Long Lake may be cut up into convenient patches, and floated out to sea. In this way it is believed the most of it may be got rid of at a trifling cost.

It is of course impossible to estimate the length of time that may be required to accomplish the work if conducted in this manner. But I am free to say, that while it is the most economical, it is also likely to prove the most expeditious, and the most effectual way of removing the material. Twice every day, rain or shine, fair or foul, night and day, winter and summer, the operation continues, and with increasing effect from month to month, until it is found necessary to put a final stop to it.

In no other way will it be possible to deal so effectually with the quick-sands which are more than likely to be met with in the course of the excavation. A running sand cannot be excavated, but it can be washed away by a very moderate current. This point alone should decide the question.

If the most of the material can be thus disposed of, instead of covering valuable marine marsh lands with useless spoil banks, then the width of land required for the canal can be reduced with advantage.

It will naturally be asked, what is to become of the five or six millions of cubic yards of stuff washed out of this canal if removed in this way? The greater part, I think, will be thrown into the shallow water of Baie Verte, and will there, by the force of the east winds, to which this Bay is open, be deposited chiefly along the shore, and go to form valuable marine marsh lands for the benefit of the proprietors along this coast. The rest will settle on the shallows of this bay which are not now, and never will be of any use for navigation.

It is not likely the fishery grounds in Baie Verte can receive any permanent injury from this accession to its mud deposits because it is well known

that the more valuable shad fisheries of Cumberland Basin have a bottom precisely similar to that which this material will supply.

On the other hand, it will do little or no harm to send back to Cumberland Basin a small fractional portion — an infinitesimal amount of the same material, which in the ages that are past, its own waters have thrown upon the land; while the scour at the mouth of the Laplanche will materially improve this entrance to the canal and possibly prepare better sites for the two entrance locks.

THE CONTRACTS.

If the works are conducted in the manner here suggested, it will be for the advantage of the contractor, as well as for the interest of the Government, that the canal should be let either in one contract, or certainly in not more than two contracts; making the division in the latter case at the mouth of the Tidnish.

The contract from Laplanche to Tidnish should be let in one bulk sum, with a schedule of prices attached, merely for the convenience of making the progress estimates. The contractor to take the risk and benefit of the scouring operations, and, with the approval of the resident Engineer, directing the works in his own way, so as to receive the full benefit of the scouring process.

The contract from the mouth of the Tidnish to Roach's Head should be let only by schedule prices.

I have the honor to be,

Sir,

Your obedient servant,

SAMUEL KEEFER,

M. Inst., C. E.

Ottawa, 18th February, 1873